A HIGH-SCHOOL COURSE IN APPLIED CHEMISTRY

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The recent recognition that the high schools are not to be regarded primarily as preparatory institutions for the universities and colleges of the state has resulted in a general awakening among principals and superintendents with reference to high-school courses of study in Wisconsin. There is current a strong feeling that a larger part of the high-school curricula should be a direct preparation for the future life-work of the pupils. This feeling manifested itself recently at a meeting of The Superintendents' and Supervising Principals' Association, when resolutions were passed asking the higher educational institutions of the state to be more liberal in their entrance requirements, especially with reference to commercial and industrial work. A further phase of this same movement is the desire to make subjects that are already in the curricula yield a larger measure of practical value. This feeling is particularly strong with reference to the sciences, and especially in the case of physics. In this branch it has been greatly augmented by the campaign which Mr. H. L. Terry, inspector of high schools, is conducting against the present teaching of physics in secondary schools.[1]

The writer purposes in this series of articles to describe the work of the Menomonie High School in the effort to make its science work more practical. The articles will describe the courses in chemistry, physics, and botany, as they are conducted at the present time. These courses are not to be regarded as final, nor are they suggested as a scheme to be adopted bodily by another school.

Chemistry in the Menomonie High School is an optional subject in all courses except the industrial course, where it is required. It may be elected during either the junior or the

[1] Cf. H. L. Terry, "Four Instruments of Confusion in Teaching Physics," *School Review* (April, 1910), VIII, 241–45.

senior year, and in certain cases sophomores are allowed to take it. The first semester is devoted to a thorough study of the basic principles and phenomena. In order to cover this work in an adequate manner it has been necessary to reduce the subject-matter to the fundamentals, leaving out much that is in the average textbook. This has resulted in one decided improvement—the elimination of much of the non-essential, theoretical work, likely to be so dear to the heart of the specialist and worth so little to the high-school student. During the second semester two lines of study are carried on. The girls study household chemistry and the boys have industrial chemistry. To facilitate progress boys and girls are put into separate sections. In fact, they are segregated from the beginning, but this is more a matter of convenience than of necessity as far as the work of the first semester is concerned.

The character of the work may perhaps best be made evident by a synopsis of the course and a few of the experiments.

The work in household chemistry may be grouped under three heads: the chemistry of foods, of bread-making, and of cleaning. The different classes of foods and their general reactions are studied. Whenever it is possible the different food-principles are extracted from the foods in which they commonly occur. For example, in the study of proteids, collagen is extracted from bone and converted into gelatin. Tests are made on the solubility of syntonin in lean meat. Studies are made on albumin from eggs, casein from milk, and a proteid from some vegetable. In the study of sugars, glucose is prepared by the hydralization of starch which the student has previously extracted from potatoes. An effort is made to familiarize the student with the common food-stuffs and with the changes they undergo in cooking.

The work in bread-making includes the fermentation process, a study of the necessary and favorable conditions for the growth of the yeast, with regard to food-supply, moisture, and temperature. In connection with the study of bread raised by the non-fermentative process, baking-powder and soda are subjects of consideration. Tests are made for ammonium,

cream of tartar, phosphate, and sulphate powders. A cream-of-tartar powder is prepared, the best proportionate amounts of soda and tartrate being determined by experiment. The reactions of various acids, such as hydrochloric, lactic, and tartaric, with soda, are noted; also the reactions of acid salts.

The chemistry of cleaning involves a study of the chemical nature of stains, such as grease, blood, paint, rust, ink, fruit, tea, coffee, and grass stains, with the different cleaning reagents and their proper application. A kitchen cabinet of cleaning reagents is prepared and labeled as to composition and use.

The following experiment is chosen from the work on soap-making:

> Dissolve 15 g. of potassium hydroxide in 120 c.c. of water and pour half of this into a procelain evaporating dish of at least 500 c.c. capacity; add 60 c.c. of water and 50 g. of tallow. Boil this solution for three-quarters of an hour, carefully replacing from time to time the water which has been lost by evaporation; then add the remainder of the solution of potassium hydroxide and boil at least an hour more. Water should be added as before, but the volume of the liquid may be allowed to decrease about one-third. Cool. What are the properties of soft soap? Use? Add 20 g. of salt, boil for a few minutes, and allow the liquid to cool. The soap will rise to the top, and the glycerine, excess of lye, and salt will remain in solution. Write chemical equation representing reaction for formation of soap.

The industrial chemistry for the boys covers a study of clays and brick-making, cements, mortars and glazes, the sources and preparation of illuminating gases, fuels, the softening of water and tests of its purity, bleaching and oxidizing agents, the extraction and clarification of beet-sugar, making of matches, the denaturing and quick vinegar processes, alloys and amalgams, covering the preparation of brass and solder, preparation of common compounds, manufacture of pigments and inks, blow-pipe analysis of some native minerals, electrolysis and electroplating, preparation of varnishes and stains, a little work in photography, and some agricultural chemistry. In this course certain basic work is required of all. Beyond this there is some individual adaptation of experiments, so that each pupil does not personally conduct work in all of the subjects indicated.

The following experiment is chosen from the study of fuels:

To determine the fixed carbon in coal.—Heat about 2 gm. of pulverized coal in a porcelain crucible closely covered, as long as any smoke is given off. Weigh. To what is the loss of weight due? What remains in the crucible? Heat the remainder, with cover removed, in a blast flame until all the carbon is burned out. Weigh. The second loss in weight represents the fixed carbon in the coal. The incombustible remainder is ashes. Compare your results with the following table:

	Water	Volatile Matters	Fixed Carbon	Ash
Lignite	18.00	20.00	50.90	10.20
Bituminous ..	1.97	38.60	54.15	4.10
Cannel	undet.	37.20	61.60	1.20
Anthracite ...	3.09	4.28	83.81	8.18

Compare the retail prices of the above coals and their fixed carbon content. Would this hold true if we lived in a coal-mining district? Why? Coke has a high carbon content. Its price is relatively low. Why?

Since the course as described has been conducted, with more or less modification, for six years, the writer feels that the results obtained are worthy of more consideration than if they were mere speculations. As previously stated, the work is elective in all courses except one. Notwithstanding this fact, from eighty-five to ninety per cent of the students completing the high-school work have elected chemistry. This may be regarded as a fair test of its appreciation by the students. Teachers feel that it gives the pupils a better training than would be obtained from a course in pure chemistry. This, I believe, is largely due to the fact that the students learn to think more clearly with reference to things chemical than do students who spend the whole year on theoretical chemistry. That the subject thus treated has greater value for the student who does not go beyond high school cannot be denied. The pupils taking this course we find are able to do good work in college or university chemistry. Since the course has been in operation graduates of the high school have entered at least three of the large universities of the Middle West and have pursued chemistry farther. Almost without exception these students have ranked well in chemistry—decidedly above the average. In one case a student entering a

university was admitted to second-year work in college chemistry and acquitted herself with credit.

Mr. W. M. Smallwood, in his discussion of "Some Problems in Secondary Science Teaching," in the April number of *School Science and Mathematics,* states that the teachers who "are in the process of cutting loose from 'the technical exactness of university methods' are blown hither and yon by 'humanized survey,' 'commercial,' 'hygiene,' or utilitarian motives. It is possible that they will have a pleasant sail while the water is smooth and they do not try to make a landing." Our experience has satisfied us that the teaching of chemistry with a utilitarian purpose in view need not result in lack of direction. Quite the contrary has been the case. We have found that pupils are not only able to reach port and effect a landing, but know where they are after landing, which is not true in the majority of cases where the subject is taught for the sake of pure science.[2]

[2] The writer wishes to acknowledge his indebtedness to the instructors who have worked out this course. The course was started by Mr. A. H. Christman, formerly instructor in chemistry in Stout Institute and in the Menomonie High School. The household chemistry was developed and organized by Miss Zella Perkins, now instructor in chemistry in Stout Institute. The industrial chemistry is largely the work of Mr. W. F. Roecker of the Menomonie High School.